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ORIGINAL

FLOOD INSURANCE STUDY

COMPLETED

32

CITY OF LYNDEN, WASHINGTON
WHATCOM COUNTY

MAY 3, 1982

Federal Emergency Management Agency

COMMUNITY NUMBER-530202

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Exhibit 2 - Flood Boundary and Floodway Map

PUBLISHED SEPARATELY:

Flood Insurance Rate Map

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1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study investigates the existence and severity of flood hazards in the City of Lynden, Whatcom County, Washington, and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study will be used to convert Lynden to the regular program of flood insurance by the Federal Emergency Management Agency. Local and regional planners will use this study in their efforts to promote sound flood plain management.

In some states or communities, flood plain management criteria or regulations may exist that are more restrictive or comprehensive than those on which these federally supported studies are based. These criteria take precedence over the minimum Federal criteria for purposes of regulating development in the flood plain, as set forth in the Code of Federal Regulations at 24 CFR, 1910.1(d). In such cases, however, it shall be understood that the State (or other jurisdictional agency) shall be able to explain these requirements and criteria.

1.2 Authority and Acknowledgments

The source of authority for this Flood Insurance Study is the National Flood Insurance Act of 1968, as amended.

The hydrologic and hydraulic analyses for this study were performed by the U.S. Soil Conservation Service, Spokane, Washington, for the Federal Emergency Management Agency, under Inter-Agency Agreement No. IAA-H-9-76, Project Order No. 14. This work, which was completed in May 1981, covered all significant flooding sources affecting Lynden.

1.3 Coordination

Initial selection and identification of streams requiring detailed study were done in a meeting on February 27, 1976, attended by representatives of the City of Lynden, the Washington State Department of Ecology, the Federal Emergency Management Agency, and the study contractor.

The final coordination meeting was held on September 24, 1981, and was attended by representatives of the Federal Emergency Management Agency, the study contractor, and the city. No problems were raised at the meeting.

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2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the incorporated areas of the City of Lynden, Whatcom County, Washington. The area of study is shown on the Vicinity Map (Figure 1).

Approximately 2 miles of Nooksack River and 4 miles of Fishtrap Creek were studied by detailed methods. The limits of detailed study were determined by the Federal Emergency Management Agency with community and study contractor consultation at the meeting in February 1976. There are no other streams identified in the City of Lynden that pose a potential flood threat.

Those areas studied by detailed methods were chosen with consideration given to all proposed construction and forecasted development through 1986.

2.2 Community Description

The City of Lynden, located in northern Whatcom County, in northwestern Washington, had a 1980 population of 3970. The economy of the area is moderately diversified, including light industry, agriculture, and tourism.

Ferndale, Washington, is 8 miles to the west, and Bellingham, Washington, 15 miles south of Lynden. The City of Seattle lies 104 miles to the south. The dominant geologic feature near Lynden is Nooksack River. Moderate temperatures are characteristic of the Puget Sound regions in Washington. The average monthly low and high temperatures are 30°F in January and 74°F in July, respectively. Average annual precipitation is approximately 40 inches, with most falling from November through March.

Vegetative cover within Lynden ranges from clear areas of pasture to small clumps of fir and alder. Soils are nearly level to gently undulating. They are formed in the alluvial flood plain of Nooksack River and have a seasonal high water table. Soils include Puyallup fine sandy loam, Rifle peat, and Lynden sandy loam.

2.3 Principal Flood Problems

Flooding in Lynden occurs mainly in the winter months, when storms with high winds cause storm surges. The principal areas of flooding occur along the streams. These areas have been left in agriculture with only a few farmsteads within the 100-year flood plain.

Nooksack River is known to have flooded nine times during the 69-year period from 1909 to 1978. These floods occurred in 1909, 1917, 1921, 1932, 1935, 1937, 1949, 1951 (Reference 1) and 1975.

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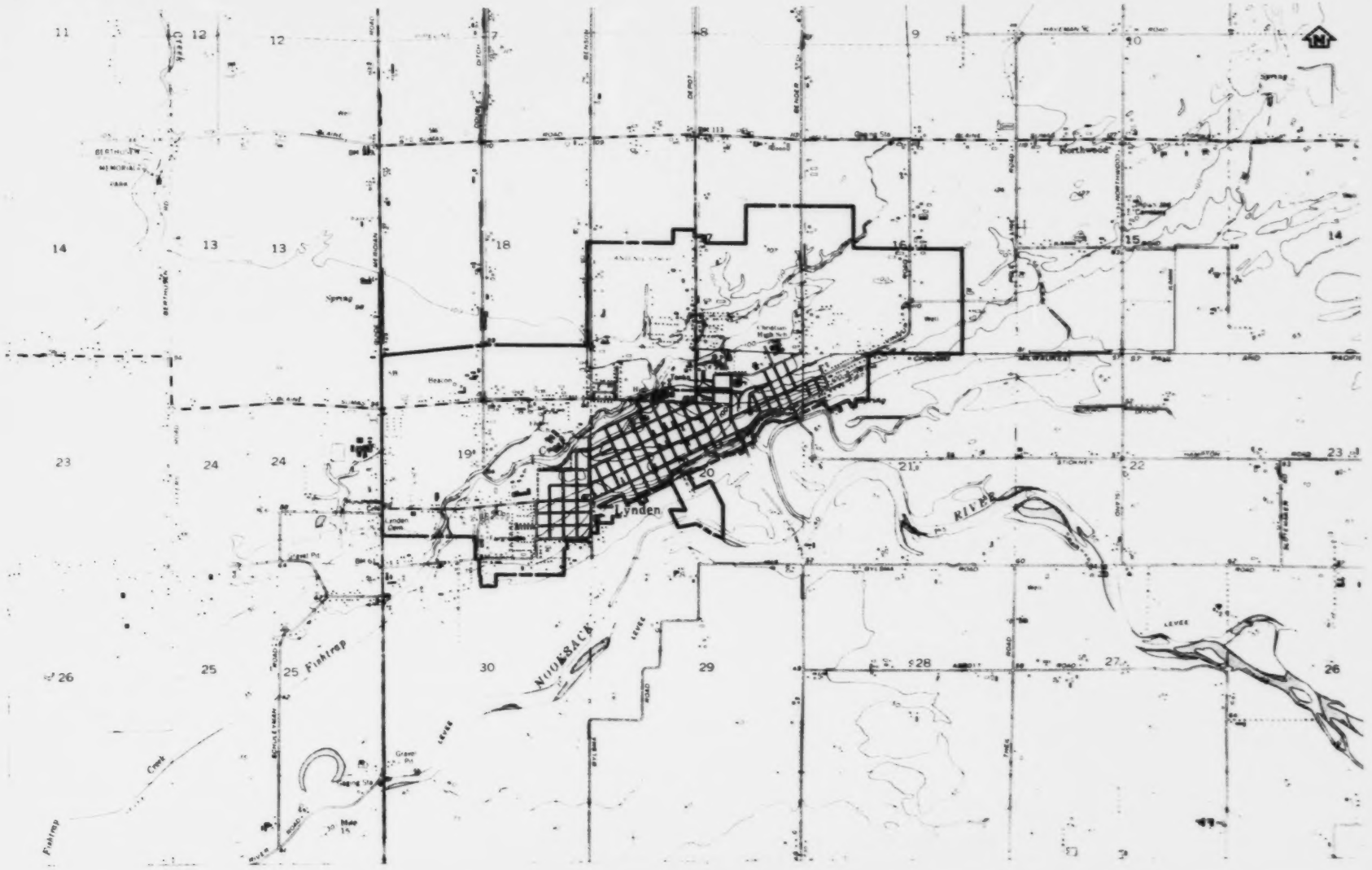

FIGURE 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF LYNDEN, WA
(WHATCOM CO.)

APPROXIMATE SCALE

3,575 0 3,575 7,150 10,725 FEET

VICINITY MAP

No records of floods caused by heavy precipitation within the watershed have been found. The largest flood with estimated discharges was the 1932 flood, with a return interval of 32 years. The 1909 flood was greater than the 1932 flood, but no estimates of discharge have been found. During 1975, floodwater was flowing over bottom lands along Nooksack River. It was also observed to have crossed several roads and flooded many acres of agricultural land in the vicinity of Lynden. This was approximately an 11-year event.

2.4 Flood Protection Measures

Nooksack River has been diked through the City of Lynden. This will protect the farmland from a 10-year frequency flood event.

The Shoreline Management Act, administered by the State of Washington, restricts building within 200 feet of a navigable river.

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude which are expected to be equalled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for flood plain management and for flood insurance premium rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10, 2, 1, and 0.2 percent chance, respectively, of being equalled or exceeded during any year. Although the recurrence interval represents the long term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood which equals or exceeds the 100-year flood (1 percent chance of annual occurrence) in any 50-year period is approximately 40 percent (4 in 10), and, for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported here reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for floods of the selected recurrence intervals for each flooding source studied in detail affecting the community.

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Streamflow records, along with the synthetic hydrograph method were used to calculate floodflows. The method used was the U.S. Soil Conservation Service TR-20 computer program (Reference 2), which predicts the peak flow at specific locations based upon precipitation, land use, soil type, topography, and used unit hydrograph techniques. This part of the model was verified using a method developed by the U.S. Geological Survey (Reference 3).

Peak discharge-drainage area relationships for Nooksack River and Fishtrap Creek are shown in Table 1.

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of the flooding sources studied in the community were carried out to provide estimates of the elevations of floods of the selected recurrence intervals along each of these flooding sources.

Water-surface elevations for Nooksack River and Fishtrap Creek were computed using the U.S. Soil Conservation Service WSP-2 computer program (Reference 4). This part of the model computes the backwater of the streams based upon physical characteristics of the channel, bridges, and overbank flow. These water-surface profile elevation-discharge relationships were used to establish flood elevations for the various events at each of the surveyed cross sections.

Cross section data for Nooksack River were obtained from aerial photographs flown in 1964 (Reference 5) and from field surveys in 1978. Cross section data for Fishtrap Creek were obtained from a 1961 U.S. Soil Conservation Service Watershed Survey (Reference 6).

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway is computed (Section 4.2), selected cross section locations are also shown on the Flood Boundary and Floodway Map (Exhibit 2).

Hydraulic roughness coefficients (Manning's "n") used in the computations were chosen by engineering judgment and based on field observations of the streams and flood plain areas, and are as follows:

Description	Manning's "n"
Overbank area-dense brush	0.070
Overbank area-dense trees	0.100
Street-asphalt	0.016
Channel-riprap	0.035
Channel-natural	0.025 to 0.040

Table 1. Summary of Discharges

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-Year	50-Year	100-Year	500-Year
Nooksack River					
At Hannegan Road	636.0	38,639	48,610	52,063	55,185
Fishtrap Creek					
At U.S. Geological Survey Gage	24.1	493	614	665	781

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Starting water-surface elevations for Nooksack River were taken from a study of high water on Puget Sound (Reference 7).

Starting water-surface elevations for Fishtrap Creek were taken from the flood profiles for Nooksack River.

Flood profiles were drawn showing computed water-surface elevations to an accuracy of 0.5 foot for floods of the selected recurrence intervals (Exhibit 1).

All elevations are referenced to the National Geodetic Vertical Datum of 1929 (NGVD). Elevation reference marks used in the study are shown on the maps.

The hydraulic analyses for this study are based on unobstructed flow. The flood elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

4.0 FLOOD PLAIN MANAGEMENT APPLICATIONS

The National Flood Insurance Program encourages State and local governments to adopt sound flood plain management programs. Therefore, each Flood Insurance Study includes a flood boundary map designed to assist communities in developing sound flood plain management measures.

4.1 Flood Boundaries

In order to provide a national standard without regional discrimination, the 100-year flood has been adopted by the Federal Emergency Management Agency as the base flood for purposes of flood plain management measures. The 500-year flood is employed to indicate additional areas of flood risk in the community. For each stream studied in detail, the boundaries of the 100- and 500-year floods have been delineated using the flood elevations determined at each cross section; between cross sections, the boundaries were interpolated using stereographic interpretations, field flood plain mapping, historical high-water marks, and topographic maps at a scale of 1:24,000, with a contour interval of 5 feet (References 5 and 8).

Flood boundaries for the 100- and 500-year floods are shown on the Flood Boundary and Floodway Map (Exhibit 2). In cases where the 100- and 500-year flood boundaries are close together, only the 100-year flood boundary has been shown. Small areas within the flood boundaries may lie above the flood elevations and, therefore, not be subject to flooding; owing to limitations of the map scale, such areas are not shown.

4.2 Floodways

Encroachment on flood plains, such as artificial fill, reduces the flood-carrying capacity, increases the flood heights of streams, and increases flood hazard in areas beyond the encroachment itself. One aspect of flood plain management involves balancing the economic gain from flood plain development against the resulting increase in flood hazard. For purposes of the National Flood Insurance Program, the concept of a floodway is used as a tool to assist local communities in this aspect of flood plain management. Under this concept, the area of the 100-year flood is divided into a floodway and a floodway fringe. The floodway is the channel of a stream plus any adjacent flood plain areas that must be kept free of encroachment in order that the 100-year flood may be carried without substantial increases in flood heights. Minimum standards of the Federal Emergency Management Agency limit such increases in flood heights to 1.0 foot, provided that hazardous velocities are not produced. The floodways in this report are presented to local agencies as minimum standards that can be adopted or that can be used as a basis for additional studies.

The floodways presented in this study were computed on the basis of equal-conveyance reduction from each side of the flood plain. The results of these computations were tabulated at selected cross sections for each stream segment for which a floodway was computed (Table 2).

As shown on the Flood Boundary and Floodway Map (Exhibit 2), the floodway widths were determined at cross sections; between cross sections, the boundaries were interpolated. In cases where the boundaries of the floodway and the 100-year flood are either close together or collinear, only the floodway boundary has been shown.

The area between the floodway and the boundary of the 100-year flood is termed the floodway fringe. The floodway fringe thus encompasses the portion of the flood plain that could be completely obstructed without increasing the water-surface elevation of the 100-year flood more than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to flood plain development are shown in Figure 2.

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FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Nooksack River								
A	17.5	3051/140[2]	15,582	3.3	54.3	54.3	55.3	1.0
Fishtrap Creek								
A	3.04	33	162	4.1	52.4	52.4	53.4	1.0
B	3.60	59	151	4.4	62.6	62.6	63.6	1.0
C	4.05	39	152	4.4	72.1	72.1	73.1	1.0
D	4.40	73	211	3.2	76.5	76.5	77.5	1.0
E	4.86	33	136	4.9	87.7	87.7	88.7	1.0
F	5.34	45	171	3.9	94.6	94.6	95.6	1.0
G	5.68	45	189	3.5	99.8	99.8	100.8	1.0

[1]Miles Above Mouth [2]Width/Width Within Corporate Limits

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF LYNDEN, WA
(WHATCOM CO.)

FLOODWAY DATA

NOOKSACK RIVER-FISHTRAP CREEK

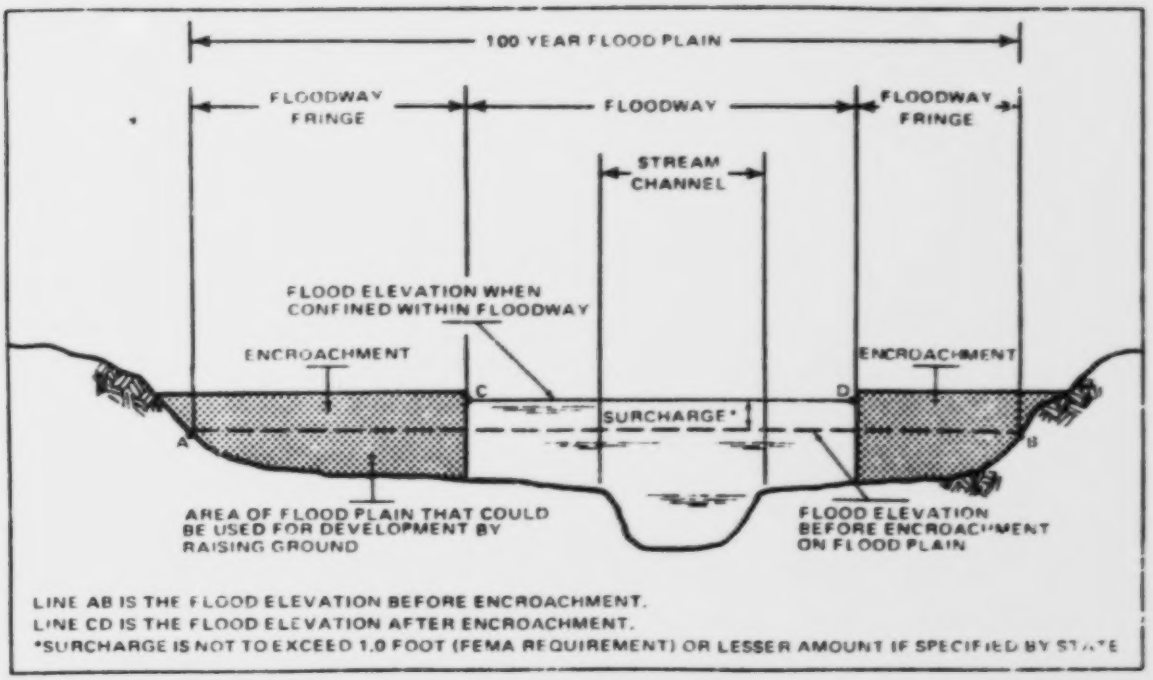
100 YEAR FLOOD PLAIN
FLOODWAY FRINGE
FLOODWAY
FLOODWAY FRINGE
STREAM CHANNEL
FLOOD ELEVATION WHEN CONFINED WITHIN FLOODWAY
ENCROACHMENT
ENCROACHMENT
C
D
SURCHARGE*
A
B
AREA OF FLOOD PLAIN THAT COULD BE USED FOR DEVELOPMENT BY RAISING GROUND
FLOOD ELEVATION BEFORE ENCROACHMENT ON FLOOD PLAIN
LINE AB IS THE FLOOD ELEVATION BEFORE ENCROACHMENT.
LINE CD IS THE FLOOD ELEVATION AFTER ENCROACHMENT.
*SURCHARGE IS NOT TO EXCEED 1.0 FOOT (FEMA REQUIREMENT) OR LESSER AMOUNT IF SPECIFIED BY STATE

Figure 2. Floodway Schematic

5.0 INSURANCE APPLICATION

In order to establish actuarial insurance rates, the Federal Emergency Management Agency has developed a process to transform the data from the engineering study into flood insurance criteria. This process includes the determination of reaches, Flood Hazard Factors (FHFs), and flood insurance zone designations for each flooding source studied in detail affecting Lynden.

5.1 Reach Determinations

Reaches are defined as lengths of watercourses having relatively the same flood hazard, based on the average weighted difference in water-surface elevations between the 10- and 100-year floods. This difference does not have a variation greater than that indicated in the following table for more than 20 percent of the reach:

Average Difference Between 10- and 100-Year Floods	Variation
Less than 2 feet	0.5 foot
2 to 7 feet	1.0 foot
7.1 to 12 feet	2.0 feet
More than 12 feet	3.0 feet

The locations of the reaches determined for the flooding sources of Lynden are shown on the Flood Profiles (Exhibit 1) and summarized in Table 3.

5.2 Flood Hazard Factors

The FHF is the Federal Emergency Management Agency device used to correlate flood information with insurance rate tables. Correlations between property damage from floods and their FHF are used to set actuarial insurance premium rate tables based on FHFs from 005 to 200.

The FHF for a reach is the average weighted difference between the 10- and 100-year flood water-surface elevations expressed to the nearest one-half foot, and shown as a three-digit code. For example, if the difference between water-surface elevations of the 10- and 100-year floods is 0.7 foot, the FHF is 005; if the difference is 1.4 feet, the FHF is 015; if the difference is 5.0 feet, the FHF is 050. When the difference between the 10- and 100-year water-surface elevations is greater than 10.0 feet, accuracy for the FHF is to the nearest foot.

5.3 Flood Insurance Zones

After the determination of reaches and their respective FHFs, the entire incorporated area of Lynden was divided into zones, each having a specific flood potential or hazard. Each zone was assigned one of the following flood insurance zone designations:

Zones A2 and A3:	Special Flood Hazard Areas inundated by the 100-year flood, determined by detailed methods; base flood elevations shown, and zones subdivided according to FHFs.
Zone B:	Areas between the Special Flood Hazard Areas and the limits of the 500-year flood, including areas of the 500-year flood plain that are protected from the 100-year flood by dike, levee, or other water control structure; also areas subject to certain types of 100-year shallow flooding where depths are less than 1.0 foot; and areas subject to 100-year flooding from sources with drainage areas less than 1 square mile. Zone B is not subdivided.
Zone C:	Areas of minimal flooding.

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1% (100-YEAR) FLOOD AND			FLOOD HAZARD FACTOR	ZONE	BASE FLOOD ELEVATION (FEET NGVD)[3]
		10% (10-YEAR)	2% (50-YEAR)	0.2% (500-YEAR)			
Nooksack River Reach 1	0001	-1.4	-0.4	0.4	015	A3	Varies - See Map
Fishtrap Creek Reach 1	0001	-0.8	-0.2	0.3	010	A2	Varies - See Map

[1]Flood Insurance Rate Map Panel [2]Weighted Average [3]Rounded to Nearest Foot

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF LYNDEN, WA
(WHATCOM CO.)

FLOOD INSURANCE ZONE DATA

NOOKSACK RIVER-FISHTRAP CREEK

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The flood elevation differences, FHFs, flood insurance zones, and base flood elevations for each flooding source studied in detail in the community are summarized in Table 3.

5.4 Flood Insurance Rate Map Description

The Flood Insurance Rate Map for Lynden is, for insurance purposes, the principal result of the Flood Insurance Study. This map (published separately) contains the official delineation of flood insurance zones and base flood elevation lines. Base flood elevation lines show the locations of the expected whole-foot water-surface elevations of the base (100-year) flood. This map is developed in accordance with the latest flood insurance map preparation guidelines published by the Federal Emergency Management Agency.

6.0 OTHER STUDIES

The U.S. Army Corps of Engineers published a Flood Plain Information report for Nooksack River in 1964 (Reference 5). The present Flood Insurance Study has used the same cross section data for development of the flood profiles, but the present profiles were computed by a more recently developed backwater computation routine (multiple portion) (Reference 4) and are considered to be more reliable than those shown in the Flood Plain Information report.

A study published by the Pacific Northwest River Basins Commission in 1970 gives background and history of flooding in Whatcom County and makes planning projections and recommendations for flood control measures (Reference 9).

A Flood Hazard Boundary Map for Lynden was published in 1976 (Reference 10). This study supersedes the Flood Hazard Boundary Map.

A revised Flood Insurance Study is being prepared for the unincorporated areas of Whatcom County (Reference 11). This study is consistent with the Whatcom County study.

This study is authoritative for the purposes of the National Flood Insurance Program; data presented herein either supersede or are compatible with all previous determinations.

7.0 LOCATION OF DATA

Survey, hydrologic, hydraulic, and other pertinent data used in this study can be obtained by contacting the Natural and Technological Hazards Division, Federal Emergency Management Agency, Federal Regional Center, 130 228th Street, SW., Bothell, Washington 98011.

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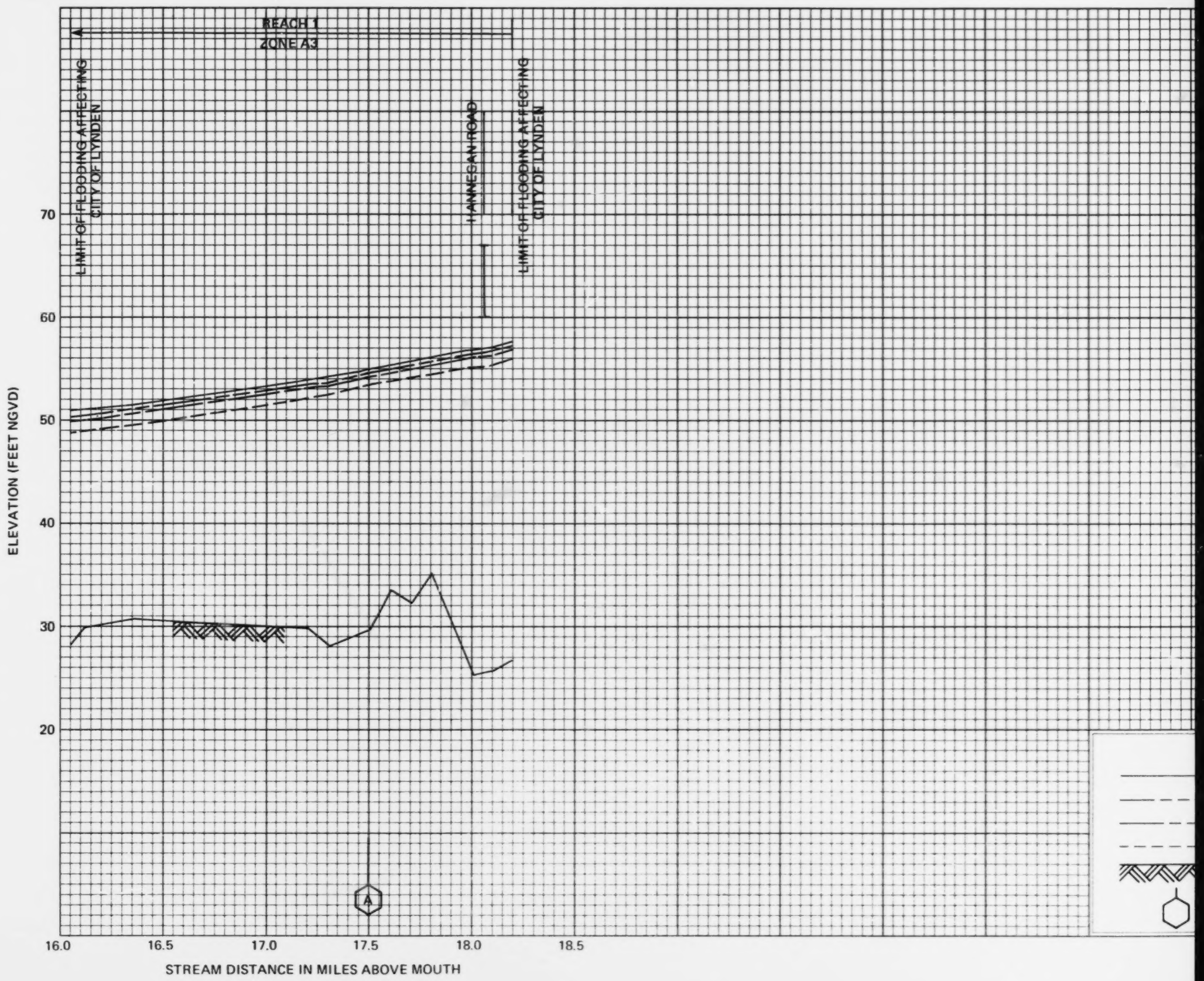
REACH 1
ZONE A3
LIMIT OF FLOODING AFFECTING CITY OF LYNDEN
HANNEGAN ROAD
LIMIT OF FLOODING AFFECTING CITY OF LYNDEN
ELEVATION (FEET NGVD)
70
60
50
40
30
20
A
16.0
16.5
17.0
17.5
18.0
18.5
STREAM DISTANCE IN MILES ABOVE MOUTH

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ACH 1
NE A3

HANNEGAN ROAD

LIMIT OF FLOODING AFFECTING CITY OF LYNDEN

17.5 18.0 18.5

CE IN MILES ABOVE MOUTH

LEGEND

- 500 - YEAR FLOOD
- 100 - YEAR FLOOD
- 50 - YEAR FLOOD
- 10 - YEAR FLOOD
- STREAM BED
- CROSS SECTION LOCATION

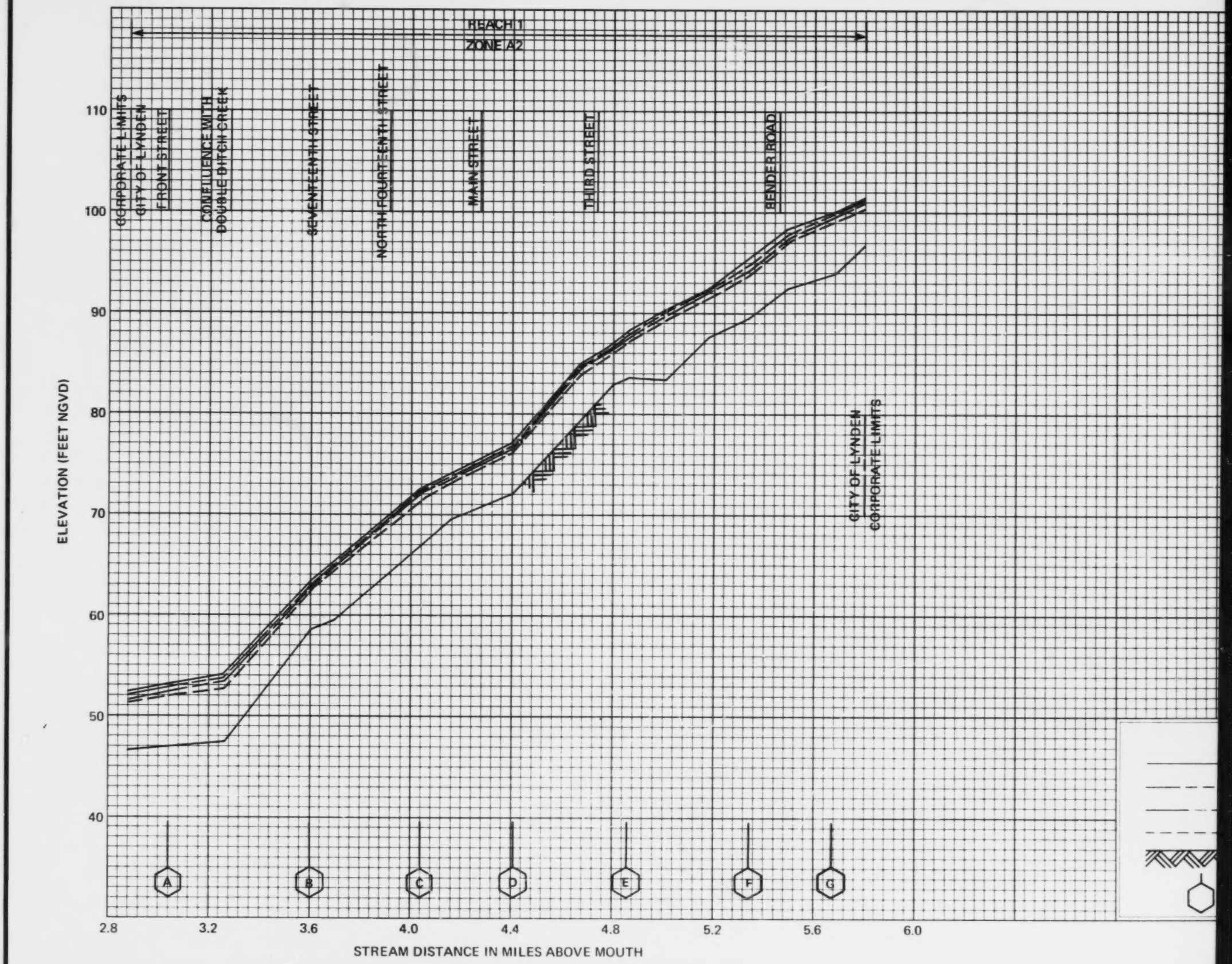
FLOOD PROFILES

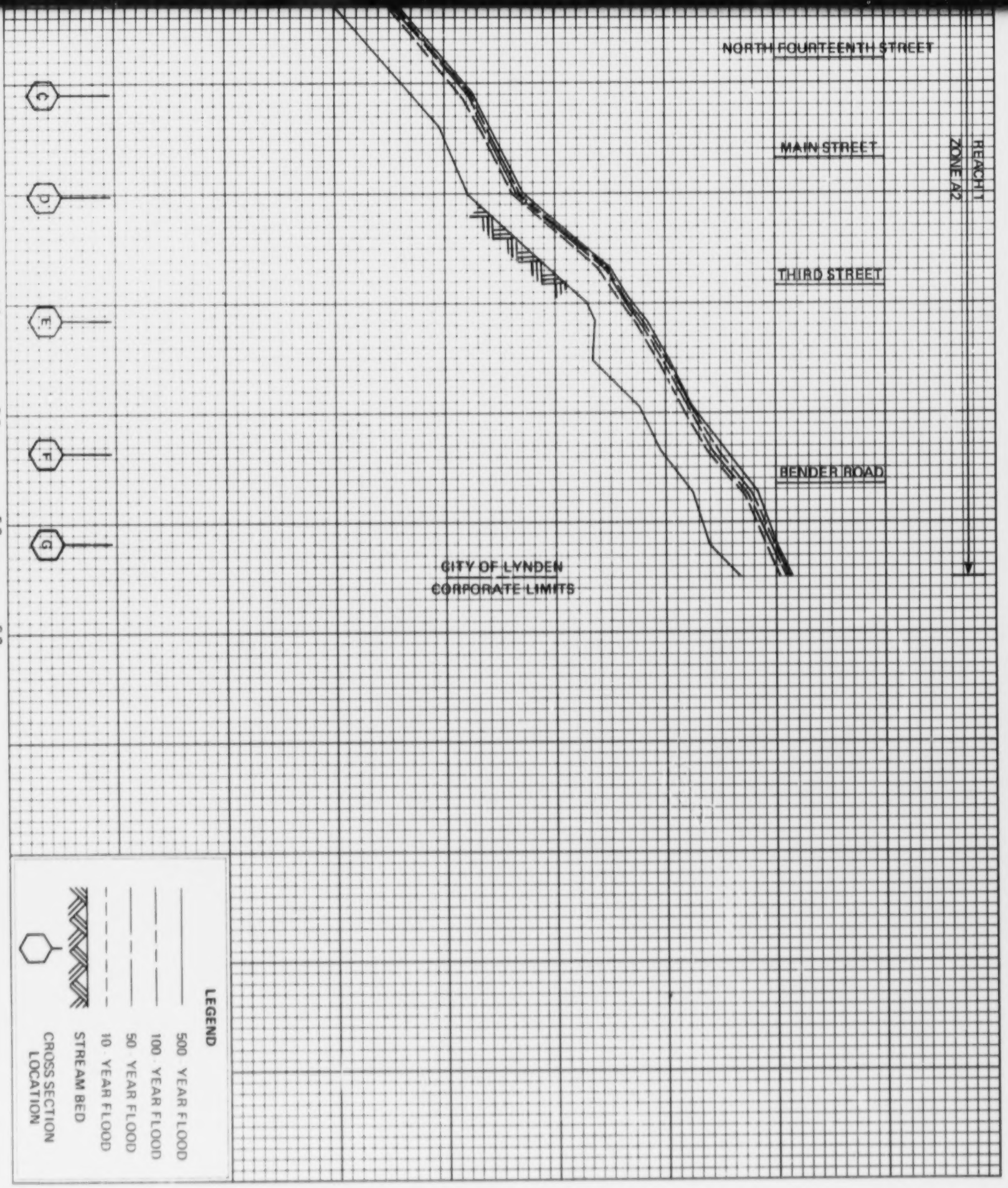
NOOKSACK RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF LYNDEN, WA
(WHATCOM CO.)

01P


REACH 1
ZONE A2
CORPORATE LIMITS
CITY OF LYNDEN
FRONT STREET
CONFLUENCE WITH
DOUBLE DITCH CREEK
SEVENTEENTH STREET
NORTH JUDSON STREET
MAIN STREET
THIRD STREET
BENDER ROAD
CITY OF LYNDEN
CORPORATE LIMITS
ELEVATION (FEET NGVD)
110
100
90
80
70
60
50
40
A
B
C
D
E
F
G
2.8
3.2
3.6
4.0
4.4
4.8
5.2
5.6
6.0
STREAM DISTANCE IN MILES ABOVE MOUTH



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02P

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF LYNDEN, WA
(WHATCOM CO.)

FLOOD PROFILES

FISHTRAP CREEK